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Methodology for Mitigation of LFGs Emission & Pollution caused by Leachate - A Literature Review

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ABSTRACT
The MSW which is formed from the household which are generally scrapped or dumped at a place which is called landfill site. Generally, the waste that is to be disposed shall be segregated and should be given primary treatment before disposal. But the practice is not carried out. When the water which comes in contact with landfill-wastes, the landfill gases (LFG) is formed as an organic part of municipal solid waste which is biodegraded. LFGs emitted consist of CH4, CO2 and are Greenhouse gases (GHGs) which endow in adverse climatic change. In India, conventional methods (clay capping) which are still implemented to decrease water penetration in landfills. Another method for reduction of landfill gases is Extraction systems for collecting gas from landfill. Also, Phytocapping method is application of plants on aged landfill sites and decrease the emission of GHGs and leachate. Moreover, Leachate is the concentrated liquid that is gathered in bottom of landfill which threats degradation of groundwater and natural water body through runoff. This paper focuses on the issues of LFGs and Leachate and methods practiced to capture LFGs to convert to bioenergy thereby mitigate the emission of GHGs and leachate to decrease further degradation of environment.

Keywords *- Bioenergy, Landfill gases, Leachate, Methane, MSW, Phytocap*

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I. INTRODUCTION

Due to rapid industrialization, growth and economically development, Municipal solid waste (MSW) ratio increased significantly. over 377 million residents resides in 7,935 towns or cities. India, huge country which is parted in 29 States and 7 Union Territories. Three mega metropolis-Greater Mumbai, Delhi, and Kolkata-having quite 10 M population, 53 towns have about 1 million population, and 415 towns having population 100,000 or more (Census, 2011) [1]. MSW, mentioned as waste, rubbish, litter or trash, is waste consisting of day to day items discarded by the final public. In India, it's estimated that the speed of increase of solid waste generation is 1 to 1.5 % annually [2]. As per data by Pollution Control Boards 1,27,486 Tons per day MSW was generated within the country during 2011 and 2012. because of increase in solid waste generation, cumulative requirement of land for solid waste disposal is about 1400 km2 by 2047 in India [2]. The generated waste consists of non-bio or biodegradable, inert-waste. They contribute in pollution in atmosphere and foul odor. The Fig.1 shows the proportion composition of MSW (Source: CPHEEO Manual on MSW, 2005) which comprise of food garden waste and refuse (paper waste), that are highly organic in nature.

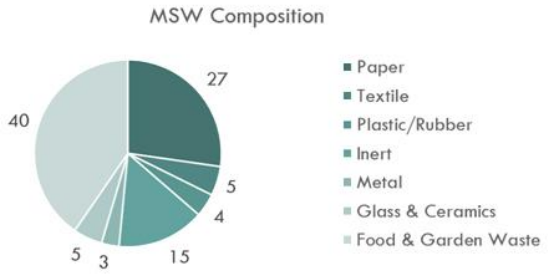

Figure 1: Percentage composition of municipal solid waste (Source: CPHEEO Manual on MSW,2005)

The waste generated is disposed off on landfill sites with none prior treatment in many parts of the planet. Thus, MSW Management is one among the main environment issue round the world. MSWM includes generation, collection, transportation, processing and disposal. However, in most Indian towns, MSWM consists of only 4 steps, namely generation, collection, transportation and disposal. MSWM, all available options for landfills are commonly used in Indian MSW management options. Traditionally, landfills are used to store waste so that exposure to humans can be minimized, thereby reducing exposure to the environment. There are many shortcomings in existing practices. this is often

due to inadequate manpower, financial resources and machinery required for efficient activities of MSWM. In most cities' segregation isn't administered. Waste is directly dumped even without compaction. the quantity of waste quantity isn't measured and is typically assessed by number of trips by transportation vehicles. India produce approximately 70 M tons of MSW yearly, of which only 5% of waste is scientifically processed (Planning Commission of India, 2011)

1.1 Landfill

The United Nations Environment Program (UNEP) explain sanitary landfill as the controlled disposing of waste, so that the contact between waste and environment is mitigated and the waste is concentrated in a limited area. Sanitary landfills or Municipal Solid Waste Landfill Sites are constructed to confine waste from the environment and makes it harmless through natural biological, chemical and physical processes. UNEP also distinguish three basic conditions which are to be fulfilled to be designated as Sanitary landfills:

a) Compacted waste,

b) Cover waste daily with soil or may be with other material

c) Handling, prevention of negative effect on everyone health and environment.

1.2 Landfill Leachate

The fluid containing many organic and inorganic compounds is called "Leachate". It may usually have suspended and dissolved substances. The formation of leachate is due to water precipitation through MSW dumped at landfills. Because of the contact with dumped MSW, the drained water becomes polluted and then it exudes out of the waste which is leachate. This is accumulated at the base of the landfills and percolates through the soil and goes within the groundwater.

The formation of landfill leachate differs greatly with the age of the landfill, so the sort of waste that's dumped thereon corresponding landfill. The major issue with leachate is that it contaminates the nearby groundwater by percolating through ground and surface water by runoff [3].

1.3 Landfill Gases

The landfill gases (LFG) such as methane, carbon dioxides, nitrous oxides, sulphur oxides are formed due to anaerobic decomposition of municipal waste on sanitary landfill sites. Landfill Gases is a summation of CH4 up to 40–45 vol.% on an average and CO2 about 55–60 vol.% on an average and N2 and other species, mostly toxic [4]. The formation of this gases leads to fire in the dumped waste and thereby causing odor problems too. In the emission of Greenhouse Gases (GHGs) India stands on fifth position in the world (MoEF, 2010) [5].

1.4 Impacts of Landfill on Environment and Surrounding

A landfill is an area of vacant land on or in which waste is disposed. Landfills of segregated MSW have become the most appropriate MSW disposal method. The landfill gases produced by an anaerobic decomposition organic part of the landfill consists of CH4 and CO2. CH4 is significant GHG from all other emitted gases. Due to activities of people, the amount of CH4 the atmosphere increased from 715 ppb before industrial age to 1,732 ppb in the early 1990s and 1,774 ppb in 2005 (IPCC, 2007). Although the amount of CH4 in the climate is less than that of Carbon Dioxide, its ability of global warming is 21x that of CO2 (IPCC, 2007). The adverse effects of the landfill are as follows

- Pollution of groundwater by landfill leachate;
- Runoff of the disposed waste will pollute surface water.
- There are foul odors, flies, rodents and wind-blown trash in and around the dump.
- Fire in the dump;
- Erosion and stability issues related to the slope of the dump;
- Acidity of the surrounding soil; and
- Releases GHGs such as CH4, N2O, and CO2

Due to population growth, lifestyle changes, poor public attitudes and poor management, solid waste generation continues to increase, and the composition of waste generation is constantly changing. As a result, people are directly at risk. In developing countries, the bad attitudes of waste producers make the situation annoying. Waste is usually thrown on the road, and rag pickers disperse it further to find recyclables or animals in search of food. As a result, the waste generated clogs the drains, causing water clogging, which is favorable to the reproduction of insects and mosquitoes that cause malaria, lymphatic filariasis and many more diseases [6]. So, this is causing risk to human life and health. Landfills often cause health problems, especially cancer, inadequate reproductive results and mortality. Landfill labors are more likely to have tissue damage and heart or lungs disease due to activation seen in white blood cells and platelets and inflammation of the airways [6].

II. METGODOLOGY

The current technologies used for LFGs mitigation and leachate treatment are either collection of methane generated in landfill sites and leachate treatment by collection of leachate through proper provision of liners or applying the plants on aged

landfill sites so as to decrease the effect of adverse effect on environment and surrounding.

2.1 Methane Recovery & Leachate Collection and Treatment

2.1.1. Methane Recovery:

Landfills which have large effect on changes in climatic and atmospheric condition. This produce CO2 and CH4. There GHG too. Together with several other gaseous components, they also cause global warming. the reason. These gases which are result of an anaerobic decomposition of organic-waste. This action turns waste without presence of oxygen [4]. Traditionally, landfill gas is collected from the solid waste layer. Since the gas escapes from the landfill surface and the leachate collection pipe, it can only collect 40-60% of the total landfill gas produced (V/V) [7]. GHG emissions in the form of CH4 are related to ozone depletion and climatic changes.

In the process of an anaerobic system degradation of MSW, various stages like hydrolysis, acid creation, ethanoic creation and CH4 are observed. because the methanogenic stage approaches, most of the absorb organic matter are turned into gas, leading to low in liquid, thereby more biogas by which we can have more energy generation, and reducing costs and leachate treatment energy [8]. CH4 is produced by landfills and exposed dumps, because the ecological components of the waste which will decompose under anaerobic condition [9]. it's observed from the fig.2 that the anaerobic system decomposes MSW.

2.1.2. Leachate Treatment:

The composition in leachates transfer station may depend on many things, including the amount of compact, waste percentage, humid nature in the waste. Generally, leachate is identified by high Chemical Oxygen Demand, pH, ammonia nitrogen and heavy metals, also with its colour and unpleasant stinky smell. Also, the features of the leachate change with its constitution and volume, and the ecological particle in the leachate changes with duration.

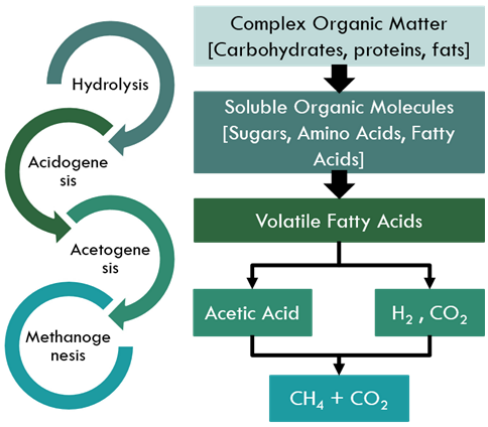

Figure 2: Degradation by anaerobic system.

Leachate contains an oversized number of organic as well as inorganic compounds, the centering of which is dependent on waste, the environment surrounding landfill, the technology for it, and also the duration of the landfill constructed. If leachate isn't properly controlled, it should infiltrate underlying groundwater and cause huge groundwater pollution. The environmental shock of leachates on landfills can last for a protracted time, possibly as long as 20 years [10]. Therefore, it's necessary to properly manage landfill leachate so as to not threaten the longer term of the environment. Current technique used of solid waste disposal in landfills includes placing layers of MSW on plastic linings to avoid leachate from percolating into groundwater. The accumulation of leachates above the liner enters the leachate collection tank through the leachate collecting tube. This is sometimes concentrated in organic pollutants, with COD as high as 40,000 mg / L [11]. As a result, collection tanks often become anaerobic and produce methane gas, which escapes into the environment, causing warming problems [12].

2.1.3. Current Methods:

The latest development of landfill Aerobic/semi-aerobic methods, in which air is diffused into waste decomposition [13]. Normally semi-anaerobic landfill consists of a big pipe, connected to other small-dia pipe below for Collection of leachates to allow air to enter easily Waste matrix through large main pipelines [14]. Leachates from semianaerobic landfill still contain high cluster of organic substances that can be converted to CH¬4 [13]. The recovery of emitted gas can be done for bio/green energies through gas piping system. Due to that a lot organic substance along with the leachates enters the leachate pool, the collecting it from the existing pipes of gas are not optimal. Gas can be often produced more by the landfills if organic substance within the leachate are often further softened into CH4 in gaseous form at the root of the landfills preceding from its sent away into the leachate collection pond. The methane gas is collected by the pipelines and converted to biomass, whereas the leachate is collected in the collection sump and lead to different treatment technologies.

2.2 Phytocapping

Phyto techniques are the new emerging attractive technique that has emerged. Phytocapping technology is taken into account to be a good, economical and environmentally friendly lowland usage technology [15]. during this technique, trees are planted / planted on the soil cowl that covers the rubbish. The soil cowl plays the role of "storage", and

also the trees play the role of "biological pump and filter", indicating that the planted trees will take away additional water than downfall and one.5-year-old plantations, the downfall interception is reduced at the most fresh water. 20% reach the soil, and these plants don't have any organic process toxicity or lack of symptoms [16].

Phytocap practicality depends on the intrinsic properties and communication between the native atmosphere, the soil and also the provided plant community. Typical Phytocap system is shown in fig. 3. The phytocaps can be used to:

- Lessen the revelation on the dumped MSW,
- To prevent percolation of moisture into landfill which creates leachate,
- Contains MSW while treatment is being applied,
- Handles gaseous emission bottom of the waste,
- Establish an acreage that can support vegetation.

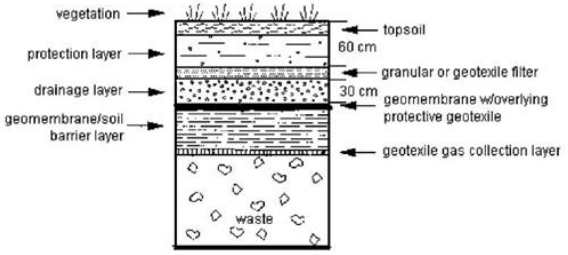

Figure 3: landfill Phytocap technique [17]

III. RESULT AND DISCUSSION

3.1 Methane recovery and leachate treatment

Biomass is produced in landfills and practiced in a variety of way, which include energy and biochar generation. If landfill is properly managed to produce biomass, it will have economic potential and environmental benefits. There are many methods and processe for solid waste management, conversion. Waste at landfill can be mechanically, biologically, or thermos-chemically converted to fuel and carbon-based products (Fig. 4).

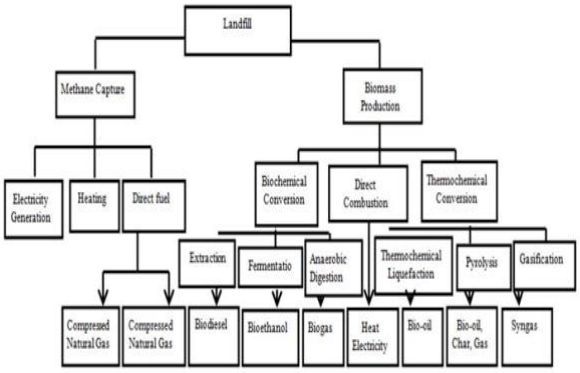

Figure 4: Common method of transformation of biomass and landfill wastes into fuels and products [18].

Thermochemical methods for converting biomass or solid waste are more inviting and have many benefits, including: high efficiency compared to biological processes, full utilization of raw materials leads to the production of multiple products, suitable for various raw materials, not affected by climatic conditions and better control of the process [19], some of these technologies can be installed on-site in landfills to generate bioenergy. Various thermochemical conversion methods, such as liquefaction, gasification and pyrolysis are suitable for the transformation of biomass with low water content (i.e. Gasification and Pyrolysis) and high water content (i.e. Liquefaction). These methods have concern, one of which is the necessity for consistent particle size prior feeding the biomass into the reactor. Therefore, various techniques of mixing, fragmentation and granulation is required. In dry gasification systems, consistent particle size is crucial for peak temperature generation rates. Smaller size particles have a greater surface area, resulting in accelerated burnout and upsurge in reactor temperature. Commonly, it takes more energy to operate the reactor plant, and it needs to reach a very high temperature to completely burn the biomass.

Over the period, various nations have implemented various waste dischare techniques for several reasons, which may be ascribe the quantity and kind of refuse generated, collection methods, available land quality, and implemented environmental regulations. In large nations with low occupants density, such as Australia, most common methods of processing solid waste are landfills. In Japan, because of the lack of space in land-scarce countries, incineration (thermal conversion method) is mainly used for waste treatment [20]. Interestingly, in many developed countries, landfills are taxed at very high rates, which hinders the disposal of landfill waste, thus motivating use of alternative MSW management practices such as waste reusing or recycling, especially in Switzerland, Germany, Netherlands. It is reported that landfill disposal in Sweden, Austria, Denmark and Belgium in 2009 was less than 5%, because of elevated landfill taxes levied on discharge on landfill site [21]. Despite the notable upsurge in reuse and recycling of MSW, the inevitable discharge to landfills remains the most universal method of Municipal Solid Waste Management (OECD, 2012).

Various techniques are presently practiced for the treatment of the landfill leachate. Most of the methods practiced are also adapted for the treatment of wastewater treatment and can be bifurcated into two prominent categories like Physical / Chemical Treatment and Biological Treatments. [22].

Few methods of the leachate treatment are listed below [23]:

• Aerobic Biological Treatment like aerated lagoons and activated sludge.
• Anaerobic Biological Treatment namely; anaerobic lagoons, reactors.
• Physiochemical treatment - air stripping, pH adjustment, chemical precipitation, oxidation, and reduction.
• Coagulation utilizing lime, alum, ferric chloride, and land treatment.
• Advanced techniques mainly carbon adsorption, ion exchange.

Rotating Biological Contractor (RBC) is proved efficient for landfill leachate treatment. The RBC is the biological treatment technology where a huge disc with radial and concentric passages rotates slowly in the concrete tank. Whilst rotation, around 40% of the disc is in the wastewater. The rotation of the disc simultaneous with the exposure to open atmosphere allows microbes to absorb the oxygen from air and leads to develop organisms and form a thin layer of biomass. This developed organic culture on the disc accelerates the degradation of the organic pollutants present in the leachate , biologically. By applying conventional ASP (activated sludge process), the aeration of leachate is carried out in an open tank equipped with aerators or diffusers [24,25].

3.2 Phytocapping

The function of the phyto-cap is to manage the infiltration of moisture into MSW, promote land runoff, minimize erosion, control odor and landfill gas oxidation [26]. Avoiding percolation of moisture into the garbage is crucial in landfill. This technology delivers magnificent prospects for the growth of plants that have the ability to clean soil polluted by metal [27]. Plant root penetration has an effect on the integrity of the clay barrier [28]. Compared with fields without vegetation, plant protection in general can reduce methane emissions from landfills by 80%. Thick cover layer has better water carrying capacity than thin cover layer [16]. Biological cover not only has the advantage of covering the entire landfill, but also provides good water retention and porosity for vegetation and evapotranspiration. Factors affecting methane oxidation include soil texture, soil moisture, temperature, pH, nutrients, oxygen concentration, and methane concentration [29]. Other advantages of phytocaps are their minimum cost, accessible resources, higher ecological site improvement and reduction of greenhouse gas emissions, phytocaps requires less skilled manpower and engineering base for maintenance and construction [28].

However, more plants for the phytocapping method are to be discovered as not all plants can take up the toxic nutrients present in the disposed MSW at landfill disposal site.

IV. CONCLUSION

Leachate can be collected from solid waste by using wells or drains, and then the gathered leachate can be processed and discarded of through a artificial recharge system, or reintroduced into a landfill. This process is commonly referred to as leachate recycling and is implemented in order to develop gas production, because it improves the ability to decompose MSW by increasing the moisture content and the transit of bacteria, nutrients and potentially suppressive waste products, it can also be used as a method to control the load of the leachate processing plant because it is completely compared to the case of drainage, the fact that recycling help the storage of leachate of landfill in a landfill itself. Reintroducing or recycling leachate back to waste also plays an important role in landfill management [30].

Major innovative and most appreciated technology for treatment of leachate is to reinstitute concentrated leachate into the landfill. With recycling the leachate, the biological part of the leachate can be decreased by the active natural communities within the MSW [31]. Thus, reuse of leachate in landfill upsurges the water proportion in the controlled reactor system and increases the transport of enzymes and nutrients between phase of methanogens in decomposition [32].

The introduction of leachate in the landfill will lead to decrease in cost of leachate treatment and will enhance the methane gas production which can later be converted in to the bioenergy by the method of biogas formation.

If the phytocapping option for the aged landfill site is more favourable due to the aesthetic purpose. The biomass received from the plants applied to the landfill site shall be used as the source of bioenergy. The methane emission can be reduced upto much extent and the other emission can be used to produce biogas which shall be used in form on bioenergy

V. FUTURE SCOPE

Due to the upsurge in industrialization and population, the generation of waste will be at peak in coming years. The world is facing the climate change issue and the need of this hour is to search for the ways to decrease the emission of methane gas and leachate formation to save our surrounding and environment and to use the emission in a way to benefit the society.

The methane gas recovery is expensive method but the generation of bioenergy from the collected methane gas is high. Low maintenance collection system shall be found so that every city in the world shall be able to implement it to gain the maximum outcome.

The phytocapping system for sanitary landfill cover is still under developing stage and much research is needed in efficiency of mitigation of methane gas and leachate generation as the plant species and the atmospheric/climatic condition are to be evaluated as per the different regions of the world

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